Vol. 13(1), pp. 41-50, January-June 2021
DOI: 10.5897/JPVB2020.0407
Article Number: AA0296E66720
ISSN: 2141-2510

http://www.academicjournals.org/JPVB

Journal of Parasitology and Vector Biology

Full Length Research Paper

Community implementation of human landing and non-human landing collection methods for *Wuchereria bancrofti* vectors

Simon P. Sawadogo[1*], Achille S. Nikièma[1], Sanata Coulibaly[1], Lassane Koala[1], Abdoulaye Niang[1], Clarisse Bougouma[2], Roland W. Bougma[2], Olivier Gnankine[3], Frances M. Hawkes[4], Daniel Boakye[5] and Roch K. Dabiré[1]

[1]Institut de Recherche en Sciences de la Santé//Direction Régionale de l'Ouest, Bobo-Dioulasso BP 545, Burkina Faso.
[2]Programme National de lutte contre les Maladies Tropicales Négligées, Ministère de la Santé, Ouagadougou, Burkina Faso.
[3]Department of Animal Biology and Physiology, Faculty of Life and Earth Sciences, Université Joseph KI-ZERBO, 03 BP 7021 Ouagadougou 03, Burkina Faso.
[4]Department of Agriculture, Health and Environment, Natural Resources Institute, University of Greenwich at Medway, Chatham, Kent, ME4 4TB, UK.
[5]Department of Parasitology, Noguchi Memorial Institute for Medical Research, College of Health Sciences, University of Ghana, Accra, Ghana.

Received 31 December, 2020; Accepted 19 February, 2021

In the drive towards elimination of lymphatic filariasis, enhanced surveillance of vector mosquitoes requires sound sampling methods which can be easily implemented and accepted by communities. Several tools have been validated as alternatives to human landing catches (HLC) for this purpose, but little is known about their effectiveness compared to HLC in terms of the vector density patterns. This study aimed at assessing the efficiency of four mosquitoes collecting tools (HLC, Center for Diseases Control (CDC) light trap, Double Net trap, Window Exit trap). These four sampling tools were evaluated in three different villages (Bapla, Ouessa and Koudjo) in Burkina Faso, when mosquito collection was managed by local people in each community. The results showed that HLC remained the most effective collection method in terms of vector abundance in all villages, followed by double net traps. Except in Bapla, the double net trap collected more *Anopheles* than CDC light traps. Across the study, the prevalence of *Wuchereria bancrofti* infection was estimated to be 0.6% and observed only in *Anopheles gambiae* sensu stricto. The Double Net trap is the least expensive of all three methods and was well accepted by the community. In conclusion, double net traps can be recommended for communities to use for lymphatic filariasis (LF) vector surveillance program for xeno-monitoring of post transmission assessment survey evaluation. Based on prevalence the mass drug administration (MDA) could be stopped in these villages without risk of resurgence of the disease, according to the current recommendations of World Health Organization (WHO). Set up surveillance and continue to use vector control tools.

Key words: Lymphatic filariasis, *Wuchereria bancrofti*, mosquitoes, community surveillance, Burkina Faso.

INTRODUCTION

Lymphatic Filariasis (LF), also known as elephantiasis, is a Neglected Tropical Disease (NTD) caused by infection

of any of three species of filarial parasites, *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori*. These parasites are transmitted to humans by mosquitoes belonging to *Anopheles, Culex, Mansonia* and *Aedes* genera (Soliman et al., 2013). *W. bancrofti* is responsible of more than 90% of cases (Opoku et al., 2018; Ottesen, 2006; Soliman et al., 2013). In Africa, LF is caused by *W. bancrofti* and usually transmitted on the continent by *Anopheles* species (Endeshaw et al., 2015). LF infection is generally asymptomatic and is acquired during the childhood. However, in chronic stages, it can involve clinical features including lymphedema, elephantiasis and others disfiguring manifestations that can lead to permanent disability and social exclusion of people who are suffering of this disease. At least 36 million people suffer from chronic disabilities resulting from LF (Ramaiah and Ottesen, 2014). In 2014, World Health Organization (WHO) targeted LF for elimination as a public health problem in the world by 2020 (WHO, 2015).

Burkina Faso was one of the first countries to conduct a national baseline LF prevalence survey at the health district level in order to estimate the burden of the disease. It resulted in an estimated 29.2% national prevalence with the highest district-level prevalence being 74% (Programme National d'Elimination de la Filariose Lymphatique Burkina Faso, 2012). Shortly following these results, Burkina Faso launched their national programme for the elimination of LF and began, in 2001, implementing MDA within four health districts. Mass Drug Administration (MDA) then scaled up rapidly across the country, such that by 2006, therapeutic coverage levels were greater than 65% in all endemic districts (The Global Atlas of Helminth Infections, 2020). As LF is a vector-borne disease, entomological assessment of parasites circulating within vector populations has been a core component of disease surveillance. In the move towards elimination, direct estimation of the presence of microfilariae in vectors is the best method to document the interruption of *W. bancrofti* transmission. However, demonstrating the end of entomological transmission requires the search for microfilariae in a large number of vectors (Dorkenoo et al., 2018). Until now, it has been difficult to obtain sufficient numbers of vectors for entomological surveillance because the use of Human Landing Catch (HLC) for collection of lymphatic filariasis vectors is becoming less acceptable on practical and ethical grounds, and not least because it requires well-trained persons and remains the most expensive method to deploy. This situation has resulted in apathy towards the use of xenomonitoring for LF in some contexts. To avoid the ethical issues and the reliance on well-trained persons from central laboratories, methods which facilitate vector collection by local communities and are simple, reliable and easy to implement must be developed. For example, the Double Net trap, comprising of a person sleeping inside a simple arrangement of nets was shown to be effective for collecting the vectors of *W. bancrofti* (Govella et al., 2011). In the context of onchocerciasis vector surveillance, the Esperanza Window Trap (EWT) has been used successfully for sampling *Simulium* species in Mexico (Rodríguez-Pérez et al., 2013a) and Burkina Faso (Toé et al., 2014).

Studies to evaluate the performance of these various trapping methods for collecting LF vectors have typically been conducted by experienced and well-trained entomologists. However, in the context of large-scale entomological surveillance of LF, use of qualified technical personnel poses an operational challenge due to the time and costs involved in training and maintaining entomological teams. There are also financial and logistical limits to the number of teams that can be deployed for activities in the field, reducing the number of localities that can be covered during surveillance (Sikaala et al., 2014). Thus, developing a similar programme of vector collection involving members of each local community could support enhanced surveillance, building on similar community-based initiatives, such as Community-Directed Treatment with Ivermectin (CDTI) under the African Programme for Onchocerciasis Control (APOC). Such a community-based direct entomological surveillance programme would promote an inclusive and economically viable assessment of the entomological transmission of this disease in space and time, which could not be achieved by the exclusive involvement of teams of qualified technicians from research centers. This approach has been successfully tested in Mexico, where the performance of the EWT trap was used for the collection of blackflies by members of the community of Chiapas for 60 days(Rodríguez-Pérez et al., 2013b). This study showed that, even though the number of *Simulium* vectors collected during this period by the community members was lower than that obtained by a team of qualified technicians, it was statistically sufficient to validate the evaluation criteria given by the WHO to estimate the interruption of transmission of the disease in the community (Rodríguez-Pérez et al., 2013b). However, there is the need to test whether this strategy could also be applied in the African context. The objective of this study was to assess the deployment of traps for collection of *Anopheles* vectors of *W. bancrofti* by a community-based approach in the Southwestern region, of Burkina Faso West Africa. Considering the endemicity of LF in the area, the prevalence of the parasite also was determined in the *Anopheles* vector, alongside the species composition of *An. gambiae* sensu lato.

*Corresponding author. E-mail: sawsimp2005@yahoo.fr.

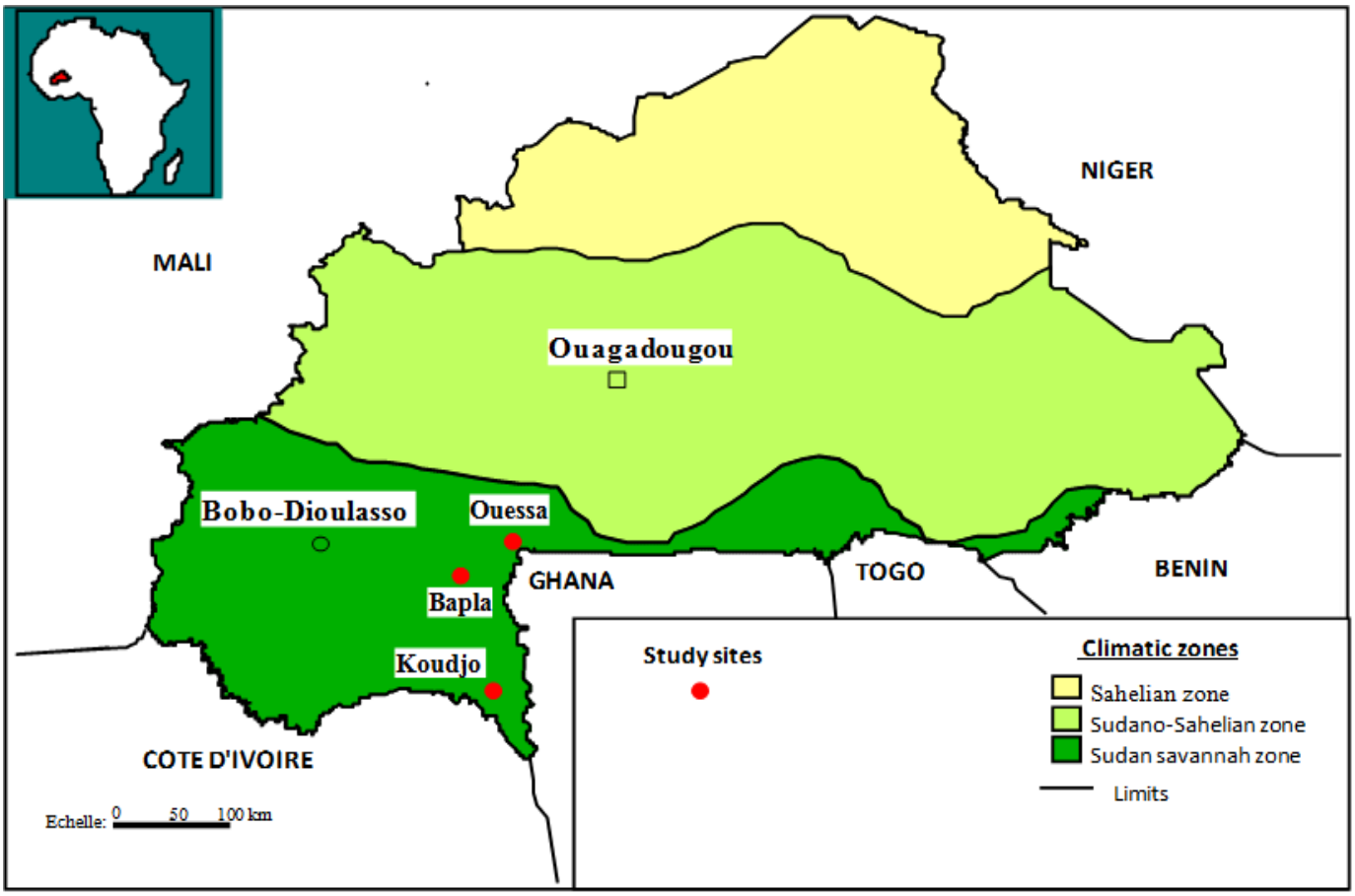

Figure 1. Location of the village study sites in the Southwestern of Burkina Faso.

MATERIALS AND METHODS

Study sites

The study was carried out in three villages, Bapla (10°53'25.83"N; 3°15'46.74"W), Ouessa (11°02'19.59"N; 2°47'7.57"W) and Koudjo (9°53'50.41"N; 2°58'43.43"W), located in Southwestern region of Burkina Faso (Figure 1). This region is endemic for LF and the three villages were randomly selected. The rainy season in the region extends from June to October and the dry season from November to May. Average annual rainfall ranges between 1000 and 1300 mm with extreme temperatures of 12 and 38°C. The principal river is the Mouhoun, which originates in the Haut Bassins region and drains into Ghana. This part of the country is characterized mainly by a vector complex including *An. gambiae* s.l. (60%), *An funestus* (37%) and *An nili* (<5%). *An. nili* is more concentrated in the highly wooded and humid savannas of the Southwestern region, where it accounted for 30% of the *Anopheles* collected using Human Landing Catch in 2003 in the zone of Gaoua. Previous entomological studies undertaken in this area (Namountougou et al., 2013) indicate that *Anopheles arabiensis* is rare and found at low frequencies, often less than 10%. This region experiences permanent transmission of malaria, highest during the rainy season and at the beginning of the dry season, and historically it has been an area of intense transmission of lymphatic filariasis; and since 2001, mass drug administration has been instituted by National Programme of Lymphatic Filariasis Elimination (Kima, 2012).

Community engagement process and volunteer training

Community engagement was initiated following meetings between a group of staff from Institut de Recherche en Sciences de la Santé (IRSS), including entomologists, community engagement specialists, and institutional management and the local authorities of each study village. During this meeting, IRSS staff presented the protocol and the study objectives, highlighting the strategies used to survey vector of diseases, focusing on malaria and lymphatic filariasis, and the importance of the role that villagers could played in supporting its success. In each village, the local authorities then selected eight people to be involved in vector collection, on the basis of the criteria suggested by IRSS staff: i) males, ii) 20 years old, iii) resident in the village and in good apparent health, and iv) able to read and write. After selection of the volunteers, the IRSS staff provided them with a one-week training course. This consisted first of showing the collectors how to collect mosquitoes using the HLC technique, the CDC light trap technique, the Window Exit trap and the Double Net trap, tools used to collect mosquitoes in this current study, according to established protocols for each method (Boakye et al., 2019; Costantini et al., 1998; Epopa et al., 2019). After initial demonstrations of the different techniques, the volunteers were supervised in using all these methods to collect mosquitoes. Then, the team taught the volunteers how to identify the genera *Anopheles*, *Culex* and *Aedes* using morphological criteria and how to correctly sort, label and store them in tubes containing silica gel desiccant to preserve them before transport to the laboratory. Finally, one of the eight volunteers was chosen as a team

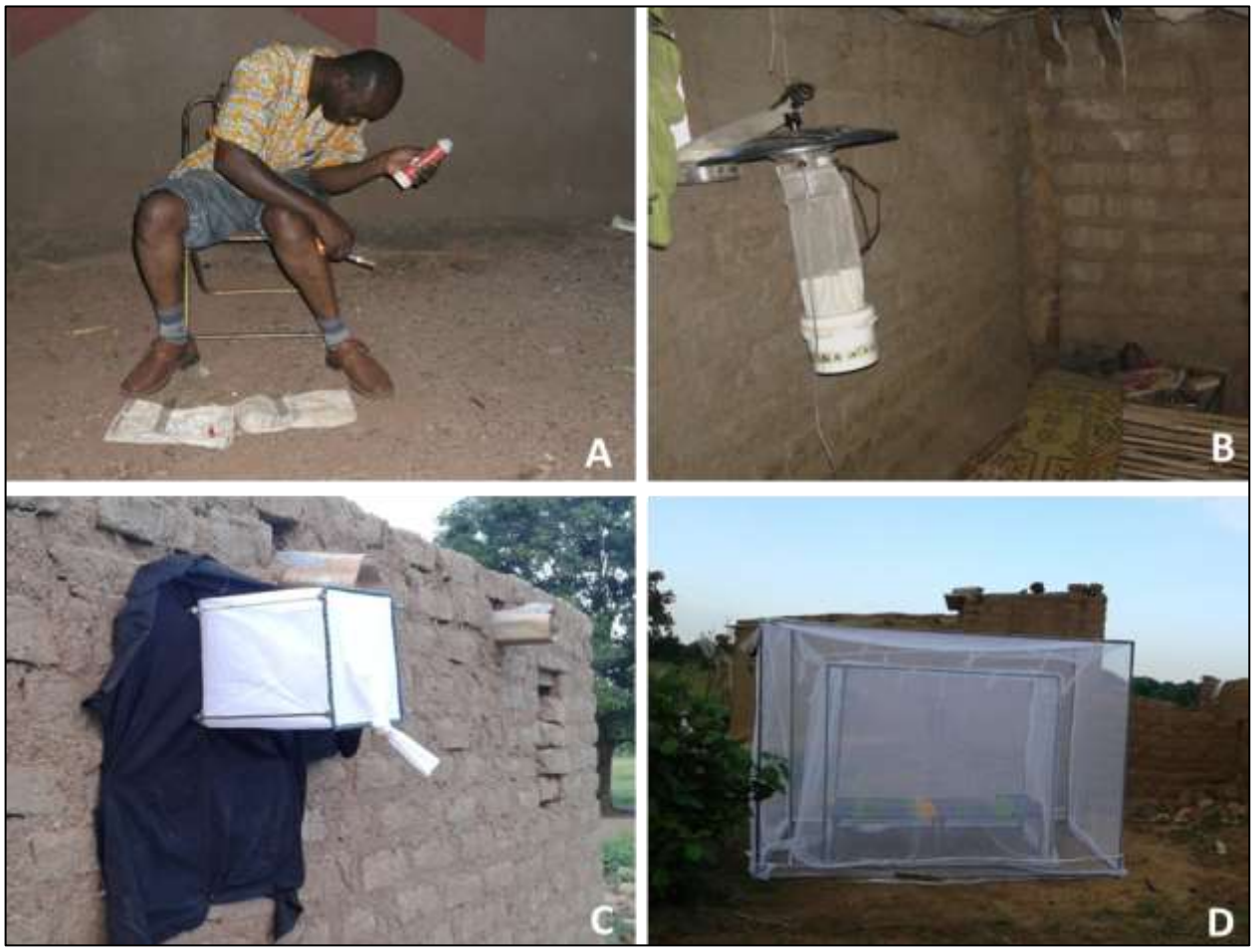

Figure 2. Sampling methods pictures used for mosquito's collection: Human landing catch (A), CDC light traps designs (B), exit trap (C) and double net trap designs (D).

supervisor and received additional training in packing, storing and shipping the samples to the laboratories at IRSS. Volunteers were provided chemoprophylaxis for the duration of the study. The sum of 4000 FCFA ($4) per day of mosquito collection was offered to the volunteers to compensate for their loss of time and effort.

Mosquito sampling by local collectors

Mosquitoes were sampled by HLC, CDC light trap, Double Net Trap and Exit Trap methods of collection for six months from June to November 2016 in each village. Collections were carried out during two consecutive nights each month (the same nights in all villages) in four houses randomly selected for each collection method. For HLC two collector stations (one indoor and one outdoor) at each house collected all skin landing (pre-biting) mosquitoes from 20:00 to 06:00 the next morning. Collectors were regularly rotated to reduce collector-mediated bias in the results and supervision was provided to ensure collectors stayed awake thus reducing any potential for biting (Figure 2A). The mosquitoes collected in each house were stored by collection origin (indoor and outdoor) and in hourly tranches. In the morning, the mosquito collectors stunned the mosquitoes by exposition to the sun and pooled them by genus into groups of 10, which were placed together in a tube with silicagel. For CDC light trap method, two traps were installed (one indoor and one outdoor) (Figure 2B). Indoor CDC light traps were suspended approximately at 1.5 to 2 m from an occupied untreated bed net generally at the foot end of the bed 1.5 m from the floor. When nets were torn or absent, new nets were provided. The outdoor CDC light trap was placed under the roof at 0.2-0.3 m from the outer wall, at approximately 1.5 m from the ground. All CDC light traps operated from 20:00 to 06:00 h. Exit traps (ET) were fitted to windows outdoor (placed in the path of flying mosquitoes) to catch mosquitoes exiting the human dwelling (Figure 2C). These traps allowed collection of mosquitoes according to their degree of normal or induced exophily. Traps were installed before sunset (5:00 PM) and emptied after sunrise (8:00 AM). For Double Net traps, two traps were installed (one indoor and one outdoor), using a person on a camp bed as "bait" (Figure 2D). The bottom of the outer net was raised about 15 cm from the ground to allow entry of mosquitoes. The collections of mosquitoes trapped during the night within the two nets were made early in the morning by a collector using a flashlight and mouth aspirator.

Shipping of the collected mosquitoes to the IRSS laboratory

At the end of the two nights of collection, each supervisor packed mosquitoes collected in a cool box and shipped them to IRSS laboratory located in Bobo-Dioulasso by local bus transporters.

Morphological and molecular identification of collected *Anopheles*

In the IRSS laboratory, morphological identification of collected mosquitoes was made according to the keys as previously described (Gillies and de Meillon, 1968, Gillies and Coetzee, 1987). After this morphological identification, only sibling species of the *An. gambiae* complex were identified by polymerase chain reaction (PCR) as previously described (Santolamazza et al., 2008).

***W. bancrofti* detection in *Anopheles* species**

Detection of *W. bancrofti* was performed on whole individuals of *An. gambiae*s., *An. funestus* and *An. nili.* Parasite DNA was extracted from whole mosquito by CTAB 2%. Positive samples were determined using the standard polymerase chain reaction (PCR)-based diagnostic tool previously described (Ramzy et al., 1997).

Data analysis

Data were entered and cross-checked in Windows Excel 2010. Statistical analyses were performed using R.4.0.3 with a significance level of 5%. Two main variables were analysed: density of mosquitoes per night and human biting rate. The biting rate from HLC, CDC light trap and Double Net trap was expressed as the number of *Anopheles* per sampling method per night. The result was obtained by the number of unfed *Anopheles* female collected at each sampling point divided by the total number of sampling days and the average number of volunteers. ANOVAs were conducted to compare the mosquito density and the biting rate between the different collection methods.

Ethical considerations

The protocol of the study received approval from the institutional ethics committee of Institut de Recherche en Sciences de la Santé (N/Réf. A16-2016/CEIRES). Engagement visits were carried out in study sites to present the project and to request the participation of villagers. During these visits, the objectives of the protocol and expected results were explained and discussed with the villagers, as well as the implications for the households willing to take part in this study. A written consent form was signed or marked with fingerprint by the head of the households before any activity could take place in his compound. At the end of the activity, local communities were informed of the results of the study in town-hall meetings. In addition, education has been provided to the local communities regarding mosquitoes biting prevention.

RESULTS

Mosquito abundance in three study sites

A total of 1,706 mosquitoes was collected during the study period in Bapla with 1,199 (70.3%), 278 (16.3%), 165 (9.7%) and 64 (3.7%) by HLC, CDC light trap, Double Net trap and Exit trap, respectively (Table 1). The majority of the mosquitoes collected were Anophelinae (74.2%). Among *Anopheles* species, proportions of 53, 14, 2.8, 2.2, 1, 1.1% were found for *An. gambiae* s.l., *An. funestus*, *An. coustani, An. nili*, *An. pharaonsis*, and other *Anopheles* species, respectively. The remaining Culicidae were *Culex* (23%), *Aedes* (0.6%) and *Mansonia* species (2.2%).

In Ouessa, a total of 1,906 mosquitoes were collected. Broken down across the trapping methods, a number of 876 (46%), 301 (15.8%), 713 (37.4%) and 16 (0.8%) by HLC, CDC light trap, Double Net trap and Exit trap, respectively (Table 1). The Anophelinae subfamily represented a proportion of 77.5% of the samples where *A. gambiae* s.l. (42.7%), *An. funestus* (8.7%), *An. nili* (5.5%), *An. coustani* (13%), *An. pharaonsis* (0.3%) and other *Anopheles* species (7.3%) were found. Other species collected were *Culex* spp (10.4%), *Aedes* spp (4.9%) and *Mansonia* spp (7.2%).

In Koudjo, a total of 625 mosquitoes were collected: 426 (68%) by HLC, 58 (9.28%) by CDC light trap, 70 (11.2%) by Double Net trap and 71 (11.36%) from Exit trap (Table 1). The majority of mosquitoes belonged to *Anopheles* genera: *An. gambiae* s.l. (88.2%), followed by *An. funestus* (3.4%), *An. nili* (3.7%), *An. coustani* (0.8%) and other *Anopheles* (1.8%). Other Culicine mosquitoes were collected in very low proportions, specifically *Culex* (1.1%), *Aedes* (1%) and *Mansonia* (0.2%) species.

The density of mosquitoes collected per night is represented in Figure 3. The data shows a significant difference according to the sampling method; in Bapla village, the HLC caught more than the three other traps ($F = 4.265$, $P< 0.05$, Figure 3A) and no significant difference was found between CDC, Double Net trap and Exit trap ($F= 0.9170$, $P = 0.42$). In Ouessa village, significantly more mosquitoes were collected with HLC than Exit trap ($t = 2.497$, $P< 0.05$) but no significant difference between CDC and Double Net trap was found ($F = 0.4646$, $P = 0.63$). Furthermore, mosquito density did not differ significantly between CDC, Double Net trap and exit trap ($F = 2.422$, $P = 0.13$, Figure 3B). In Koudjo village, the density of mosquito did not differ significantly between the four sampling methods ($F = 2.217$, $P = 0.13$, Figure 3C).

Indoor and outdoor biting rate of *Anopheles* mosquito on human estimated by HLC, CDC light traps and net trap

In Bapla village, the numbers of mosquitoes per night vary significantly according to the sampling method. In this village, HLC caught the largest number of three vectors mosquitoes indoors ($F = 4.536$, $P< 0.05$) and outdoor ($F = 9.345$, $P< 0.05$) (Figure 4A to C). Considering the HLC collection method, the mean number of mosquitoes/person/night (m/p/n) did not vary significantly between indoor and outdoor for *An. gambiae* ($t = 0.308$, $P = 0.77$), *An. funestus* ($t = 0.728$, $P = 0.51$) and *An. nili* ($t = 0.754$, $P = 0.49$). The mean number of mosquitoes/trap/night (m/t/n) did not differ significantly between CDC light and double Net traps both for indoor ($t = 1.534$, $P = 0.16$) and outdoor collections ($t = 1.603$, $P = 0.12$) of *An. gambiae* and *An. funestus* respectively

Table 1. Mosquitoes collected with four different sampling methods in Bapla, Ouessa and Koudjo villages.

Village	Sampling method	*An. gambiae sl.*	*An. funestus*	*An. nili*	*An. coustani*	*An. pharoensis*	*An. spp.*	*Culex spp.*	*Aedes spp.*	*Mansonia spp.*	Total
	HLC	661	129	36	13	15	0	320	1	24	**1199**
	CDC	157	55	1	28	2	8	17	2	8	**278**
Bapla	Double Net trap	53	44	0	7	0	10	37	8	6	**165**
	Exit trap	34	11	1	0	0	0	18	0	0	**64**
	Total	**905**	**239**	**38**	**48**	**17**	**18**	**392**	**11**	**38**	**1706**
	HLC	588	105	37	4	2	26	8	46	60	**876**
	CDC	94	39	7	51	1	21	33	30	25	**301**
Ouessa	Double Net trap	122	22	60	192	2	92	154	17	52	**713**
	Exit trap	10	0	0	1	0	1	3	1	0	**16**
	Total	**814**	**166**	**104**	**248**	**5**	**140**	**198**	**94**	**137**	**1906**
	HLC	395	4	18	2	0	0	0	6	1	**426**
	CDC	40	11	1	3	0	2	1	0	0	**58**
Koudjo	Double Net trap	59	3	2	0	0	4	2	0	0	**70**
	Exit trap	57	3	2	0	0	5	4	0	0	**71**
	Total	**551**	**21**	**23**	**5**	**0**	**11**	**7**	**6**	**1**	**625**

An: *Anopheles*; HLC: Human Landing Catch; CDC: Center for Diseases Control.

(Figure 4A, B); no *An. nili* were collected with the Double Net trap indoor (Figure 4C).

In Ouessa village, the sampling method affected also the number of mosquitoes per night. The HLC again collected the greatest number of three vectors indoor ($F = 9.952$, $P< 0.05$) and outdoor ($F = 55.94$, $P< 0.05$) (Figure 4D, E, F). However, the mean number of m/p/n was relatively similar between indoor and outdoor collection for *An. gambiae* ($t = 1.582$, $P = 0.19$), *An. funestus* ($t = 0.736$, $P = 0.50$) and *An. nili* ($t = 0.323$, $P = 0.76$). Concerning the CDC and double Net trap, no significant difference was found in the number of m/t/n between these two collection methods indoor and outdoor for *An. gambiae* ($F = 0405$, $P = 0.75$) and for *An. funestus* ($F = 2.018$, $P = 0.19$), (Figure 4DE). *An. nili* was only collected outdoor with Double Net trap in this village.

In Kodjo village, the sampling method and position was not significant impacted by the biting patterns for *An. funestus* ($F = 0.835$, $P = 0.54$) and *An. nili* ($F = 2.322$, $P = 0.08$). However, for *An. gambiae* mosquito, the mean number of mosquitoes per night indoors was higher with HLC compared to CDC and double net traps both indoor ($F = 5.119$, $P< 0.05$) and outdoor ($F = 10.77$, $P< 0.05$). The mean number of m/t/n did not differ significantly between CDC and double Net trap indoor ($t = 0. 266$, $P = 0.82$) and outdoor ($t = 1. 576$, $P = 0.17$).

Sibling species of *A. gambiae* s.l and *W. bancrofti* detection

In Bapla village, *An. gambiae* species was predominant (80.21%) followed by *An. coluzzii* (15.41%) and *An. arabiensis* (4.38%). In the same range, *An. gambiae* remained the predominant species in Ouessa (67%), followed by *An. Coluzzii* (24.14%) and *An. arabiensis* (8.04%). Analysis of the species composition according to the collection methods shown that HLC, CDC light trap, double Net trap and Exit trap (Figure 5) were able to collect all species of *An. gambiae* complex present in Bapla and Ouessa villages.

A total of 1,018 *Anopheles* were analysed for *W.*

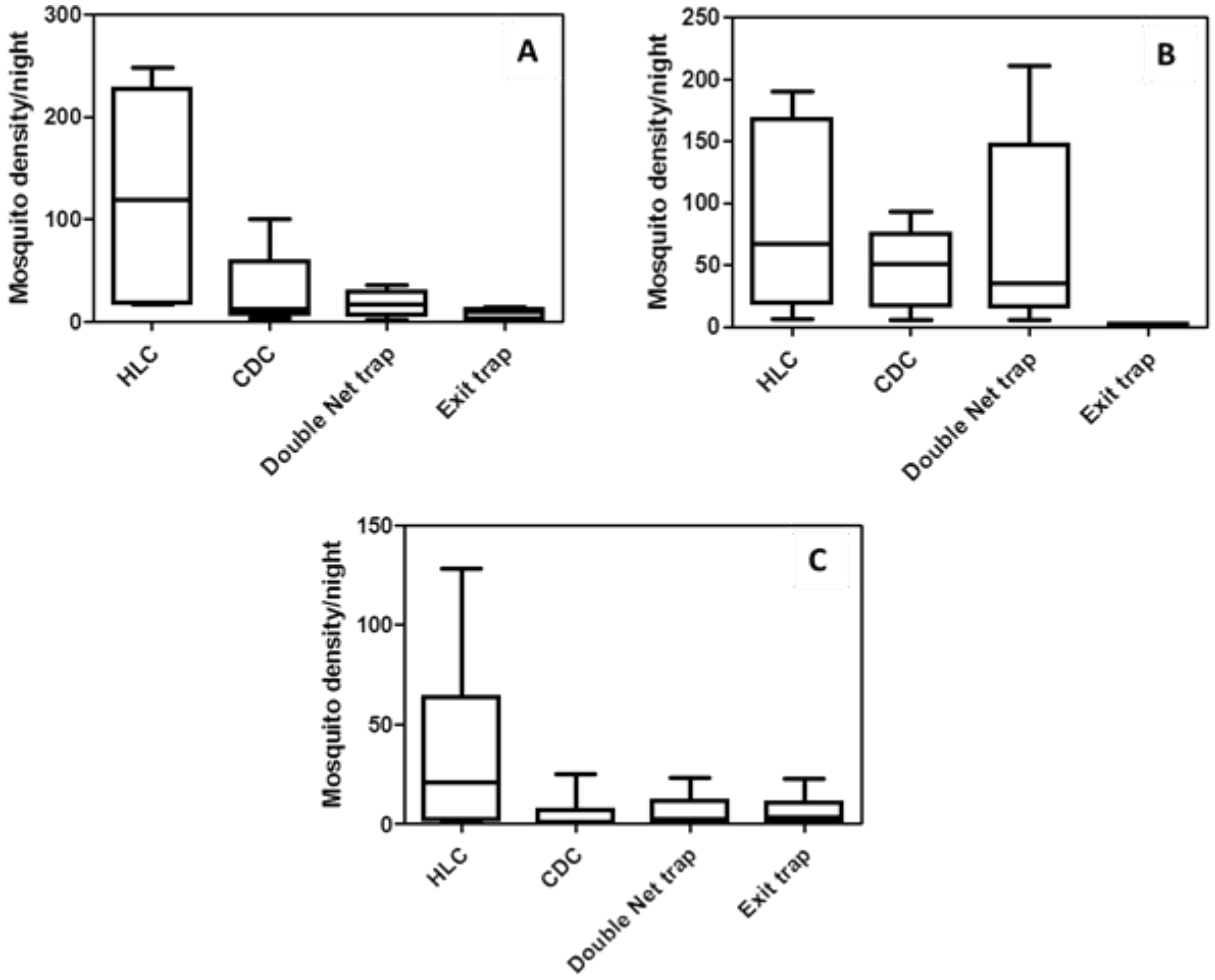

Figure 3. Mosquito abundance caught by each evaluated sampling method in each village A) in Bapla; B) in Ouessa and C) in Koudjo villages

bancrofti infection from Bapla (928 samples) and Ouessa (90 samples). The overall estimated rate of infection of all collected mosquitoes with *W. bancrofti* parasites was 0.4% (Table 2). The infection rate was significantly higher in Ouessa (2.2%) compared to Bapla (0.2%) ($P< 0.05$). Positive samples were observed only in the *An. gambiae* species. In term of collection position, the infection rate was significantly greater outdoor (0.3%) compared to indoor collection from the two villages (0.1%) ($P< 0.05$).

DISCUSSION

Although the most standard and widely-used method of collecting entomological data for LF is the HLC, the ethical concerns and cost efficacy ratio (Sikaala et al., 2013) of this tool hassled the scientific community to develop new sampling methods, such as the Ifakara tent trap (Govella et al., 2009). Some of them aimed at improving the cost which being less than that of HLC (Sikaala et al., 2014).

However, there are still debates about the most efficient method to be used for mosquito sampling and, depending on the country and its regulations, different sampling methods are used. For example, several countries in the East African region have already replaced HLC by more recent techniques such as versions of the Ifakara tent traps (Govella et al., 2009).

Communities may have a valuable role to play in supporting efforts to improve the geographical range over which LF surveillance takes places, and the duration of vector surveillance periods. This will be important in moves towards elimination, where enhanced entomological surveillance is required to detect ever lower infection rates. The reliance on trained staff from central laboratories in vector collection has mitigated against the use of entomological methods in disease monitoring and evaluation strategies. However, in the context of elimination of malaria and vector borne NTDs where large numbers of vectors are required for analysis

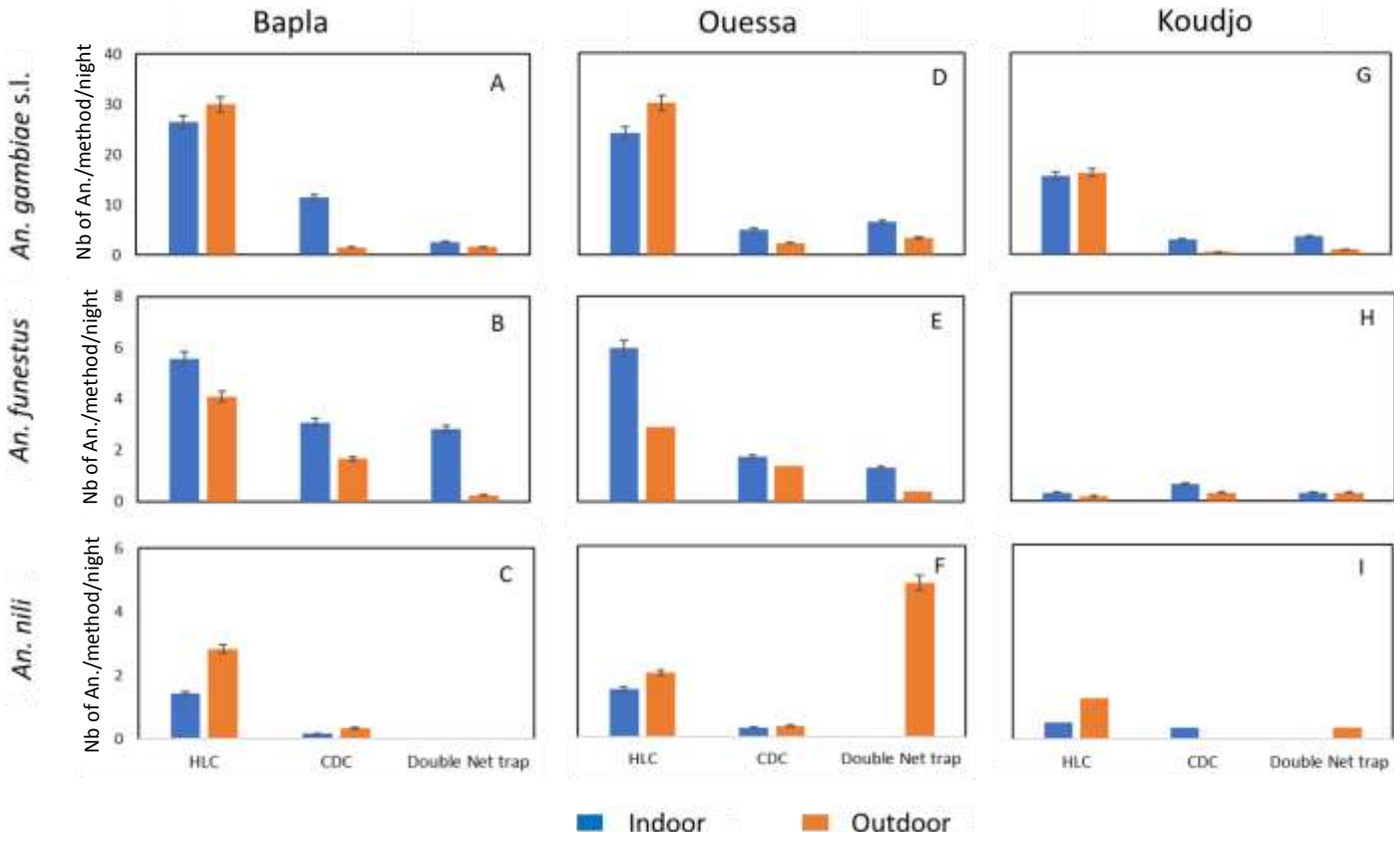

Figure 4. Mean number of *An. gambiae* sl, *An. funestus* and *An. nili* per method per night indoor (red) and outdoor (Blue) in Bapla (ABC), Ouessa (DEF), Koudjo (GHI) village.

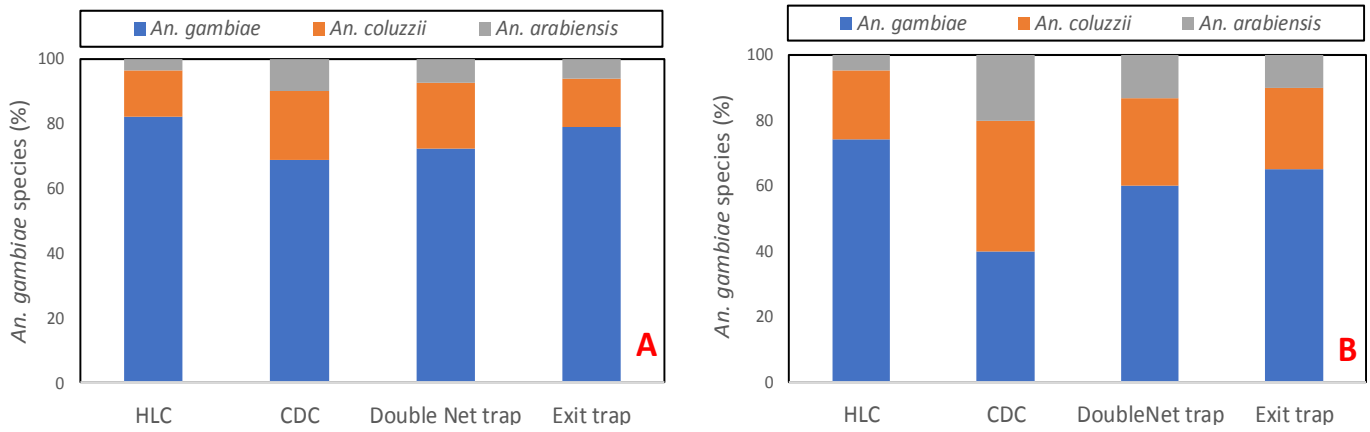

Figure 5. Proportion of *An. gambiae* species in according to the sampling method in Bapla (A) and Ouessa (B).

to determine if elimination indicators have been achieved, it is crucial to engage communities in this process. That means that different vector collection tools need to be tested in communities and by communities themselves to compare their efficiency and determine the community acceptance and use of the tools as a routine surveillance method. Implementation of this strategy in Brazil showed that the number of *Simulium* vectors collected by community members was lower than that obtained by a team of qualified technicians (Rodríguez-Pérez et al., 2013b). However, this result can be explain by aninsufficiency in the training of local community and need to be tested in Africa.

The present study tested four sampling methods

Table 2. Infection rates of *Wucheriria bancrofti* of *An. gambiae* s.l. populations from Bapla and Ouessa.

Village	Species	Site	Nb of tested	Nb of positive	Infection rate (%)
Bapla	*An. gambiae*	Indoor	266	0	0
		Outdoor	328	**2**	**0.60**
	An. coluzzii	Indoor	71	0	0
		Outdoor	45	0	0
	An. arabiensis	Indoor	9	0	0
		Outdoor	24	0	0
	An. funestus	Indoor	72	0	0
		Outdoor	60	0	0
	An. nili	Indoor	32	0	0
		Outdoor	21	0	0
Ouessa	*An. gambiae*	Indoor	23	**1**	**4.35**
		Outdoor	36	**1**	**2.78**
	An. coluzzii	Indoor	10	0	0
		Outdoor	11	0	0
	An. arabiensis	Indoor	4	0	0
		Outdoor	3	0	0
	An. funestus	Indoor	0	0	0
		Outdoor	2	0	0
	An. nili	Indoor	0	0	0
		Outdoor	1	0	0

Nn: Number; *An*: *Anopheles.*

including HLC, CDC light trap, Exit trap and a local variation of a double Net trap. Our results showed that HLC remained the most efficient in terms of number of mosquitoes collected, whatever the village and the collection places (indoor vs outdoor). It was followed by the Double Net trap which was sometimes similar to CDC traps. Regarding the biting rate estimation, HLC showed high level of *An. gambiae* s.l. biting rate especially indoors but less efficient than other methods in areas where mosquito's densities were reduced like Ouessa and Koudjo. The higher density of mosquitoes collected by HLC method can be explained by the direct access of mosquitoes to the volunteer with this method. In Ghana, a study showed that Double Net traps observed to be performing relatively better than HLC (Boakye et al., 2019). Several factors can explain this discrepancy including entomological and ecological features. In addition, our study was carried out in rainy season only and this may be a weakness of our study.

An important observation is that in area with low and medium densities of mosquitoes like Ouessa and Koudjo, the biting rates were better highlighted by the double Net Trap than did the HLC compared to the area with high mosquito density such as Bapla. This trap provides a relatively good performance similar or superior to HLC in collecting other culicidae than anophelinae. The exit traps which were placed in the tops of windows do not allow to evaluate the density of mosquitoes collected potentially in contact of humans indoors or outdoors (biting rates) but remain also a collection tool relatively less efficient but operational.

Interestingly, in term of species composition, our study showed that every collection method used in this study were efficient to collect both Malaria and LF vectors. The positive samples of filariasis infection were only found in *An. gambiae*. The absence of infection in the remaining species may be attributed to the small number of samples tested. Mass drug administration (MDA) occurred within communities in these areas.

Furthermore, in terms of communities' acceptance, we did not perform a direct questionnaire to assess these aspects, but a feedback mission remains to be organized including at *posteriori* social questionnaire on the acceptance of such community surveillance of LF vectors. This is a limit of our study. Without statistics data, the collectors would prefer to use double Net trap followed by exit traps. The main reasons were that these techniques did not need all night movements to repair

malfunctioning tools such as CDC traps or to remain awake to collect landing mosquitoes by HLC. The double Net traps provided them some protection and they need to collect mosquitoes only just the next early morning. They also found that the exit trap is simple to be used and did not need other technical skills. As we mentioned in the methodology, this point remains to be documented by *posteriori* questionnaire and focus group discussions need to be performed with the local collectors and some members of the communities on the acceptability and the perception to conduct such surveys routinely.

In conclusion, this study revealed that it is possible to involve local communities to vector surveillance and to obtain large sample sizes necessary to make validation of elimination thresholds and that community collectors preferred to use collection systems that did not involve many inconveniences at night such Double Net trap or exit traps. However, we will investigate on communities' members perception of acceptability of these tools through systematic questionnaires.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors appreciate the laboratory staff and the field teams who worked so hard to gather these data, and the community of the villages of Bapla, Ouessa and Koudjo who have been very helpful in accepting and consenting to mosquito collection. This work received financial support from the Coalition for Operational Research on Neglected Tropical Diseases (COR-NTD).

REFERENCES

Boakye DA, Frempong KK, Ogoussan KT, OtooS, Rebollo Polo M, Dadzie SK, de Souza DK (2019). Implementing a community vector collection strategy for monitoring vector-borne diseases in Ghana. Gates Open Research 3:722.

Costantini C, Sagnon NF, Sanogo E, Merzagora L, Coluzzi M (1998). Relationship to human biting collections and influence of light and bednet in CDC light-trap catches of West African malaria vectors. Bulletin of Entomological Research 88(5):503-511.

Dorkenoo MA, de Souza DK, Apetogbo Y, Oboussoumi K, Yehadji D, Tchalim M, Etassoli S, Koudou B, Ketoh GK, Sodahlon Y, Bockarie MJ, Boakye DA (2018). Molecular xenomonitoring for post-validation surveillance of lymphatic filariasis in Togo: no evidence for active transmission. Parasites and Vectors 11:52.

Endeshaw T, Taye A, Tadesse Z, Katabarwa MN, Shafi O, Seid T, Richards FO (2015). Presence of Wuchereria bancrofti microfilaremia despite 7 years of annual ivermectin monotherapy mass drug administration for onchocerciasis control: a study in north-west Ethiopia. Pathogens and Global Health 109:344-351.

Epopa PS, Collins CM, North A, Millogo AA, Benedict MQ, Tripet F, Diabate A (2019). Seasonal malaria vector and transmission dynamics in western Burkina Faso. Malaria Journal 18:113.

Gillies M, de Meillon B (1968). The Anophelinae of Africa south of Sahara (Ethiopian Zoogeographical Region).Publ. South African Institute for Medical Research 54:343.

Gillies MT, Coetzee M (1987). A supplement to the Anophelinae of Africa South of the Sahara (Afrotropical Region). South African Institute for Medical Research 55:143.

Govella NJ, Chaki PP, Geissbuhler Y, Kannady K, Okumu F, Charlwood JD, Anderson RA, Killeen GF (2009). A new tent trap for sampling exophagic and endophagic members of the Anopheles gambiae complex. Malaria Journal 8:157.

Govella NJ, Chaki PP, Mpangile JM, Killeen GF (2011). Monitoring mosquitoes in urban Dar es Salaam: Evaluation of resting boxes, window exit traps, CDC light traps, Ifakara tent traps and human landing catches. Parasites and Vectors 4:40.

Kima A (2012). Lutte contre la filariose lymphatique au Burkina Faso 2001- 2011 : Etat des lieux. Universite de Ouagadougou 1:119

Namountougou M, Diabaté A, Etang J, Bass C, Sawadogo SP, Gnankinié O, Baldet T, Martin T, Chandre F, Simard F, Dabiré RK (2013). First report of the L1014S kdr mutation in wild populations of Anopheles gambiae M and S molecular forms in Burkina Faso (West Africa). Acta Tropica 125(2):123-127.

Opoku M, Minetti C, Kartey-Attipoe WD, Otoo S, Otchere J, Gomes B, de Souza DK, Reimer LJ (2018). An assessment of mosquito collection techniques for xenomonitoring of anopheline-transmitted Lymphatic Filariasis in Ghana. Parasitology 145(13):1783-1791.

Ottesen EA (2006). Lymphatic Filariasis: Treatment, Control and Elimination. Advances in Parasitology 61:395-441.

Programme National d'Elimination de la Filariose Lymphatique Burkina Faso (2012). Rapport Annuel.

Ramaiah KD, Ottesen EA (2014). Progress and Impact of 13 Years of the Global Programme to Eliminate Lymphatic Filariasis on Reducing the Burden of Filarial Disease. PLOS Neglected Tropical Diseases 8:e3319.

Ramzy RMR, Farid HA, Kamal IH, Ibrahim GH, Morsy ZS, Faris R, Weil GJ, Williams SA, Gad AM (1997). A polymerase chain reaction-based assay for detection of Wuchereria bancrofti in human blood and Culex pipiens. Transactions of The Royal Society of Tropical Medicine and Hygiene 91(2):156-160.

Rodríguez-Pérez MA, Adeleke MA, Burkett-CadenaND, Garza-Hernández JA, Reyes-Villanueva F, CuppEW., Toé L, Salinas-Carmona MC, Rodríguez-Ramírez AD, Katholi CR, Unnasch TR (2013a). Development of a Novel Trap for the Collection of Black Flies of the Simulium ochraceum Complex. PLoS One 8:e76814.

Rodríguez-Pérez MA, Domínguez-Vázquez A, Unnasch TR, Hassan HK, Arredondo-Jiménez JI, Orozco-Algarra ME, Rodríguez-Morales KB, Rodríguez-Luna IC, Prado-Velasco FG (2013b). Interruption of Transmission of Onchocerca volvulus in the Southern Chiapas Focus, México. PLOS Neglected Tropical Diseases 7:e2133.

Santolamazza F, Mancini E, Simard F, Qi Y, Tu Z, della Torre A (2008). Insertion polymorphisms of SINE200 retrotransposons within speciation islands of Anopheles gambiae molecular forms. Malaria Journal 7:163.

Sikaala CH, Chinula D, Chanda J, Hamainza B, Mwenda M, Mukali I, Kamuliwo M, Lobo NF, Seyoum A, Killeen GF (2014). A cost-effective, community-based, mosquito-trapping scheme that captures spatial and temporal heterogeneities of malaria transmission in rural Zambia. Malaria Journal 13:225.

Sikaala CH, Killeen GF, Chanda J, Chinula D, Miller JM, Russell TL, Seyoum A (2013). Evaluation of alternative mosquito sampling methods for malaria vectors in Lowland South - East Zambia. Parasites and Vectors 6:91.

Soliman H, Mediavilla-Varela M, Antonia S (2013). Indoleamine 2,3-dioxygenase: is it an immune suppressor? Cancer Journal 16:354-359.

The Global Atlas of Helminth Infections (2020). Available at: http://www.thiswormyworld.org/maps/burkina-faso.

Toé LD, Koala L, Burkett-Cadena ND, Traoré BM, Sanfo M, Kambiré SR, Cupp EW, Traoré S, Yameogo L, Boakye D, Rodríguez-Pérez MA, Unnasch TR (2014). Optimization of the Esperanza window trap for the collection of the African onchocerciasis vector Simulium damnosum sensu lato. Acta Tropica 137:39-43.

World Health Organization (WHO) (2015). 489 Global programme to eliminate lymphatic filariasis: progress report, 2014. Relevé épidémiologique Hebdo 90:489-504.